

## **National Water Resources Outlook Web Service (12/2/2014)**

### **Background**

Water supply forecasts and information have been generated and provided to interested customers by RFCs as well as other water management agencies for many decades. Traditionally, these forecasts and supportive information have been issued on a periodic basis (e.g. monthly) and only during specific seasons (e.g. winter and spring). In most cases, these forecasts were coordinated with one or more agencies to ensure consistency and consider alternate views and information.

The strength of NOAA's Hydrology Program resides in its ability to operate real-time hydrologic modeling systems that incorporate hydrometeorological data and the latest short, medium, and long-range weather and climate forecasts. Operating in an ensemble mode, RFCs are able to provide key water resources information in a probabilistic format that informs and supports effective management decisions across the country.

The vision for the NWRO is to provide a comprehensive view of the water resources picture that reflects information, data, and forecasts that are updated on a daily basis, every day of the year. This is a major paradigm shift from the environment where water supply forecasts are issued on a monthly basis during a specific season of interest. While the units are the same, these forecasts are fundamentally different than those previously generated and issued. Another paradigm shift comes when the notion of a seasonal volume forecast (typically related to snowmelt) is expanded to a water year forecast or any other period of the year that may be of interest to water resource managers. This dramatically increases the number of locations where meaningful water resources information can be supported by operational RFC hydrologic modeling and forecasts.

A key dimension of this "comprehensive" view is consistency across the nation. Currently, RFCs involved in water resources forecasting have a variety of graphical and tabular display formats. While all are useful, they make it difficult for users who are interested in areas that cross RFC boundaries or individuals who are interested in getting a very high level view of how water availability may be varying across the country. The vision of the NWRO is to provide a consistent interface that will meet local, regional, and national interests.

While implementation efforts are beginning in the West, an explicit design feature of the NWRO is extensibility and expandability across the entire U.S. Indeed, while some of the features will take time to implement nationwide, many can be implemented right away.

## **Framework**

The NWRO is a very data heavy application interface. RFCs will be providing large datasets on a daily basis that will require statistical analysis and storage for analysis on demand by interface users.

Graphics (maps and plots) will be generated on the fly, specified through the selection of available user options. Moc-ups of all maps, plots, and tables will be provided by the project management team.

## **Web Interface Concept**

Upon arrival, the user will be presented with a map of the U.S. that shows the percent of average water year volume expected for all supported forecast locations. Locations are to be depicted as color-coded dots referenced in a legend. The map interface will be ESRI to improve navigation familiarity, and conform to NWS standards. The primary variable on the map will be:

1. Streamflow volume

Options along the side of the map will allow the user to display other supportive information including:

2. Reservoir status
3. Snow
4. Precipitation
5. Air Temperature
6. Soil Moisture

A description of each of these maps is provided on the following pages. In addition, several of the maps will allow the user to click on the desired location and show point specific graphics and tabular information. A description of the point specific displays and tables are also included in this document.

The interface “look and feel” should be consistent with either the new NWS design or that of the National Water Center (NWC).

Navigation should be as simple and straightforward as possible where mouse clicks are minimized as possible. Access to “help” sections that will assist users in the interpretation of specific information will be integrated into the design. The content of the “help” information will be provided by the Project Management (PM) team.

## **Time Line**

Initial deployment by August 1, 2015 with full implementation for CBRFC, NWRFC, and CNRFC by October 1, 2015.



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## 1. Streamflow Volume Map

1. ESRI based
  2. Points only
    - a. Colored dots w/legend
  3. All forecasts from daily RFC 365-day (or more) ensemble runs
  4. Options for:
    - a. % average (default)
    - b. % median
    - c. Change over time (limited)
      - i. Last 1,3,7,14 days
      - ii. Since first of month
      - iii. Since first of WY
    - d. Consider a variable that combines magnitude and variability
      - i. (10%-90%)/average
  5. Period selection
    - a. WY (default)
    - b. User selectable period\*
      - i. Whole months only
      - ii. Any combination of past and future
      - iii. Current month is combination of observed and forecast
    - c. Observed only (Oct.1 to date)
    - d. Forecast residual (current date through 9/30 of current WY)
  6. Date selection (default=current)
    - a. Any date for which data has been developed or archived.
  7. When a user clicks on a forecast location
    - a. See options for point level streamflow information (PLSI)
- Analysis of other user selectable periods will require (significant) processing time. It is unreasonable and wasteful to analyze all possible periods, therefore RFCs will establish (and maintain) the standard processing periods for each forecast location in addition to the WY. Upon receipt of the ensemble forecasts, the system will analyze the forecasts for each of these periods and store the information. If a user selects a period for which analysis has been performed, then the appropriately colored dots will appear on the map. For example, traditional water supply locations in the Upper Colorado may all have an April-July period identified in addition to the WY. If the user selects April-July, the dots for these locations would appear on the map.

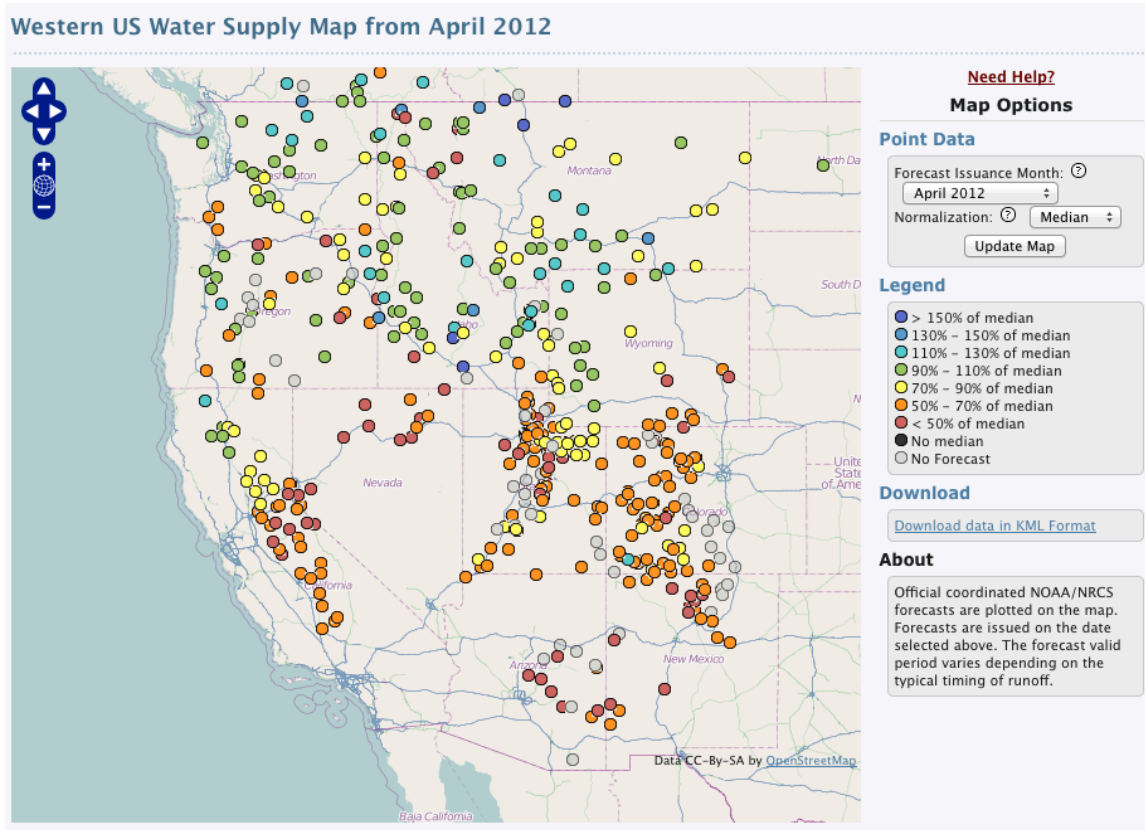


Figure 1: Example of streamflow volume forecast map. Note the options for forecast issuance date and for normalization from current WS/WRO page (wateroutlook.nwrhc.noaa.gov).

## 2. Reservoir Storage Maps

### Standard Map

1. ESRI based
2. Points based
3. Daily storage (KAF)
4. Display options
  - a. % of average (for identified date)
  - b. % of capacity
5. RFCs select reservoirs to be included
  - a. Can include both forecast and non-forecast projects
  - b. May need to “turn off” individual reservoirs due to customer sensitivity.
6. Link to inflow forecasts if available
7. When user clicks on a point:
  - a. Tea Cup diagram
  - b. WY to date plot

## Tea-Cup Diagrams

Data Current as of:  
11/04/2012

### Gunnison River Basin, CO

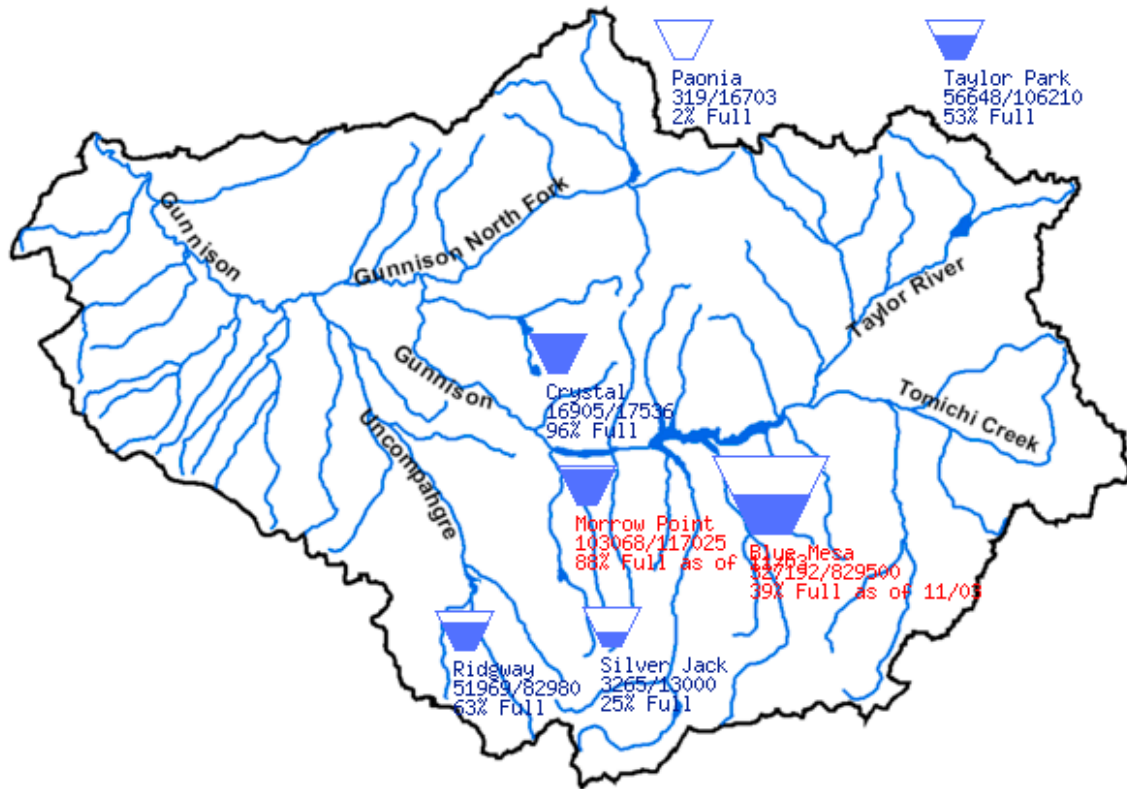


Figure 2: Tea Cup diagram example

### Aggregated Storage Map

1. ESRI
2. Solid, color-coded areas
3. Aggregation basis
  - a. States
  - b. 2 to 4 digit HUCs
4. Reservoirs within aggregated areas pooled (summed)
5. Display options
  - a. % of average (for identified date)
  - b. % of capacity
6. RFCs select reservoirs to be included
  - a. Can be both forecast and non-forecast projects
  - b. May include reservoir excluded from individual display
7. When user clicks on an aggregated area:
  - a. Tea Cup diagram
  - b. WY to date plot



- RFCs will provide either daily average storage or average first of month storage for all reservoirs to be included in this service. If first of month storage is provided, the system will interpolate the average storage for specific days.
- RFCs to provide meta data file(s) that describe any special conditions that may exist at a reservoir. For example, the reservoir may have a storage restriction due a seismic problem.

### 3. Snow Maps

#### Map w/ gridded information

1. Data from NOHRSC
2. SWE and Areal extent of snow cover (snow/no snow)
  - a. Amount
  - b. Percent of average
  - c. Change over time
    - i. Days, week, month, etc.

#### Map with point-based information

1. Reports from daily automated stations (SWE)
  - a. Need to resolve display of manual snow course observations and airborne snow survey data.
  - b. SNOTEL, CADWR data collected by NOHRSC
2. Color coded dots
  - a. Based on percent of average for selected date
3. Date selectable (default = current)
4. Clicking on point
  - a. Water year plot
  - b. Context
    - i. Average
    - ii. Analog years
      1. Multiple
      2. User selectable

System will need to database full period of record of daily snow water observations in order to compute averages and provide analog year displays.

NOHRSC is currently receiving all of these data in near real time. Leverage existing data and database structures.

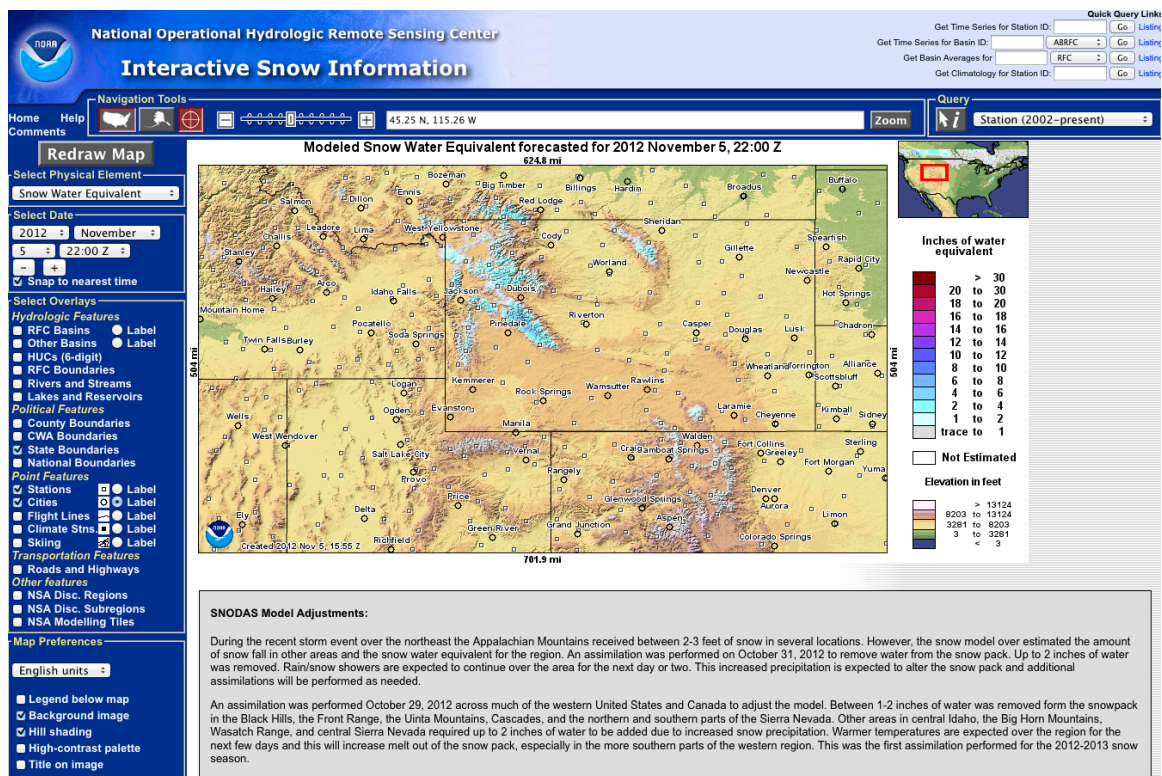


Figure 3: Current NOHRSC snow mapping website ([www.nohrsc.noaa.gov](http://www.nohrsc.noaa.gov))

#### **4. Precipitation Map**

1. ESRI based
2. Gridded information
3. Leverage existing data available through AHPS Precipitation Page.
  - a. [Water.weather.gov/precip](http://Water.weather.gov/precip)
4. Parameters
  - a. Observed precipitation (mm)
  - b. Normal (mm)
  - c. Deviation from normal (mm)
  - d. Percent of normal (%)
5. Periods
  - a. Past 1 to 7 days
  - b. Month to date
  - c. Past months
  - d. WY to date

### 30 Year PRISM Normals Have Been Updated

The precipitation images, shapefiles and downloads have been reprocessed utilizing the updated 1981-2010 PRISM normals. [Read More...](#)

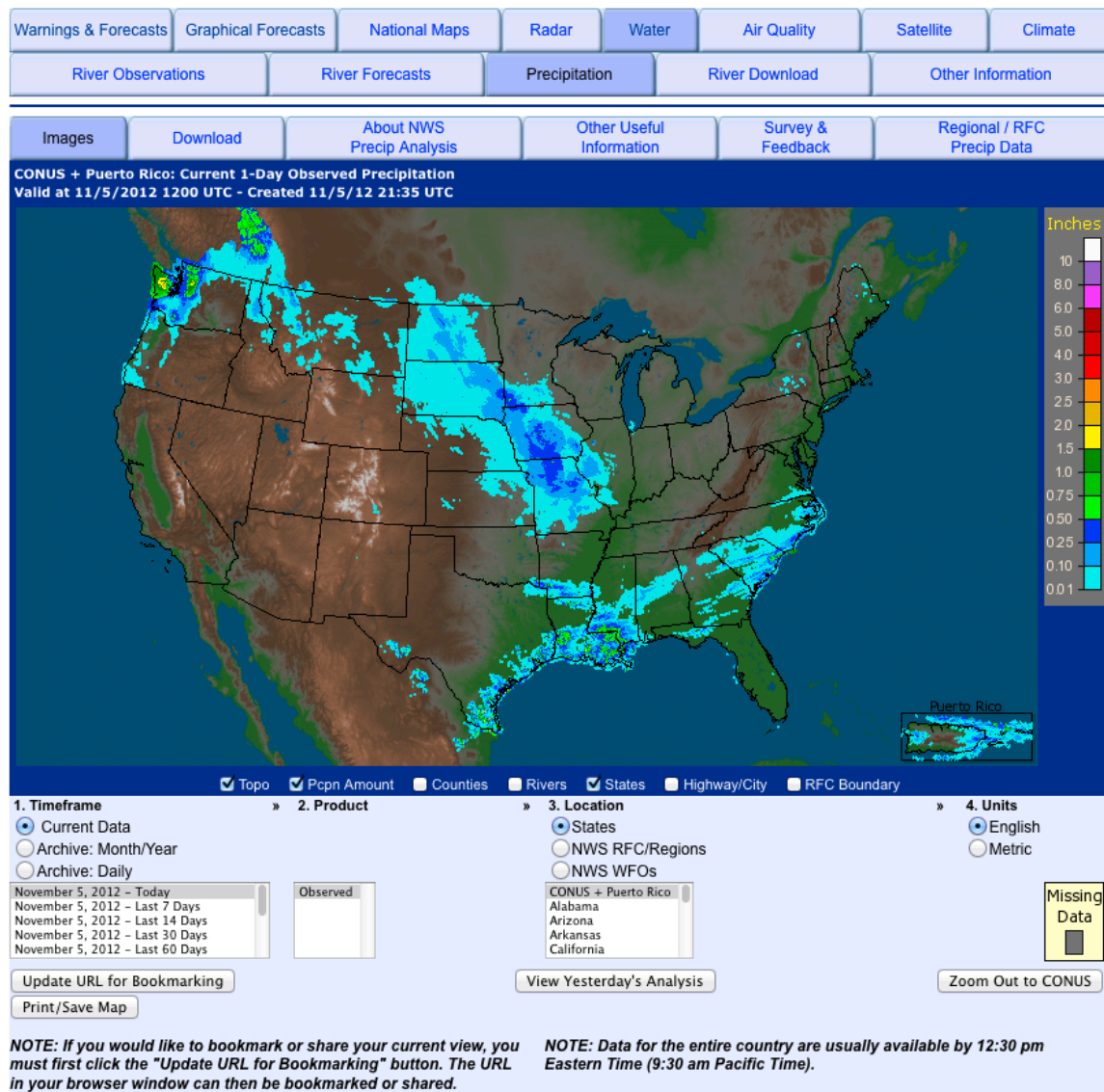


Figure 4: Current AHPS precip page (water.weather.gov/precip)

## **5. Air Temperature Map**

1. ESRI based
2. Gridded information
3. Data source is NOHRSC
  - a. Use NARR or equivalent
4. Parameters
  - a. Maximum and minimum air temperature
    - i. Observed
    - ii. Normal
    - iii. Deviation from normal
5. Periods
  - a. Past 1 to 7 days
  - b. Month to date
  - c. Past months
  - d. WY to date

## 6. Soil Moisture Maps

### Map w/ gridded information

1. Data from NOHRSC gridded mode
2. Soil moisture
  - a. Amount (mm)
  - b. Percent of average (what is average?)
  - c. Change over time
    - ii. Days, week, month, etc.

### Map with point-based information

1. Reports from daily automated stations (SM)
  - a. Will need to establish data pathway for these data
  - b. Coordinate through RFCs.
2. Color coded dots
  - a. Based on percent of average for selected date
3. Date selectable (default = current)
4. Clicking on point
  - a. Water year plot
  - b. Context
    - i. Average (if available)

## **7. Point Level Streamflow Information**

### Water Year Plot

1. Covers full water year (October 1 through September 30)
  - a. Labeled x-axis
2. Primary display elements are forecast WY streamflow volume for each day starting on October 1.
  - a. Combination of observed and forecast after October 1.
3. Primary display element (forecast volume) options
  - a. Box and whiskers
  - b. 10%, 30%, 50%, 70%, or 90% exceedance probability volume
4. Secondary display element options
  - a. Daily observed volume to date
  - b. Accumulated observed volume to date
5. Context options
  - a. Average WY volume
  - b. Median WY volume
  - c. Max and Min WY volume
6. Date
  - a. User selectable
  - b. Default is current day.
7. Small table at the bottom provides the key data for the date selected
  - a. WY forecast (90%,50%,%10 exceedance probabilities)
  - b. Observed to date



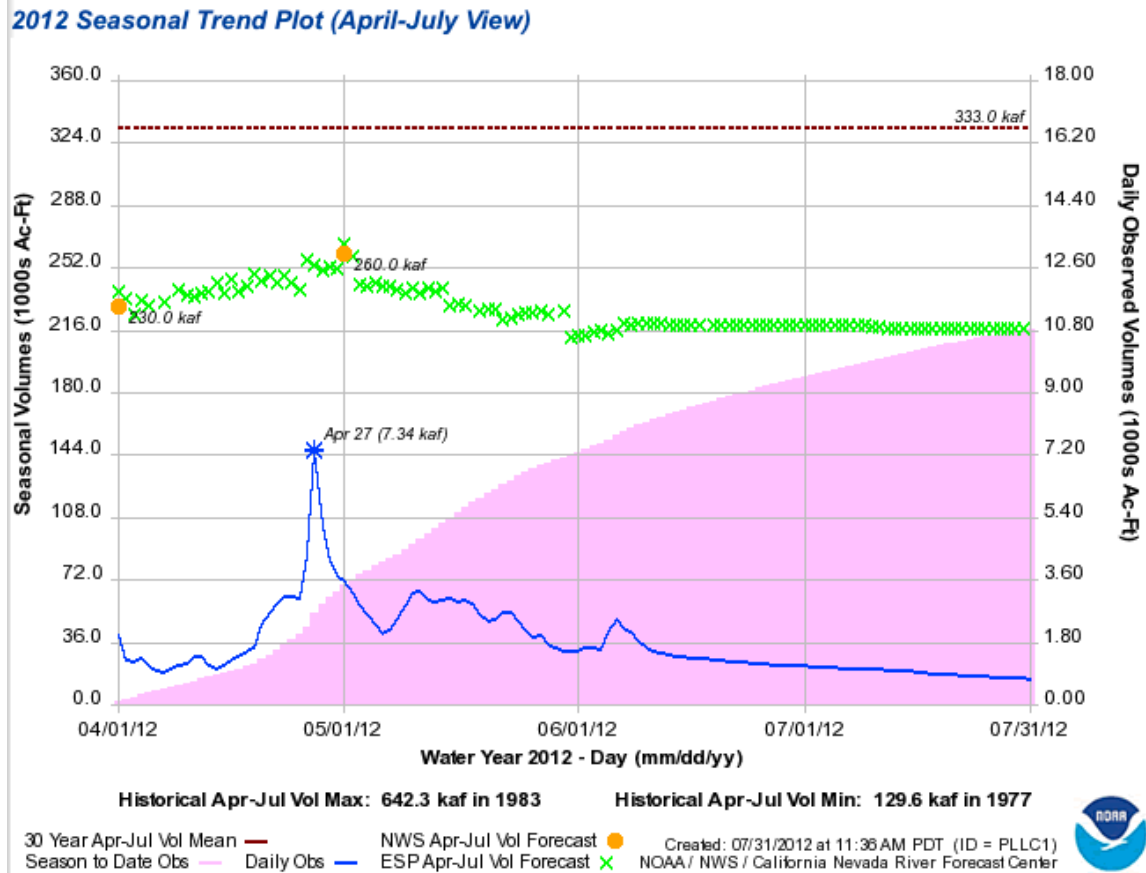


Figure 5: Example showing median forecast (green), hydrograph (blue), accumulated volume (purple), and average accumulated volume (red) over a water year ([www.cnrfc.noaa.gov](http://www.cnrfc.noaa.gov))

### User Selectable Plot

1. Similar to WY plot except the user can select any start date and end date
  - a. Start date  $\geq$  beginning of current water year
  - b. End date  $\leq$  365 days into the future
  - c. Start date < End date
  - d. Can include observed period
    - i. Or even all observed
2. Primary display elements are forecast period streamflow volume for each day starting on October 1.
  - a. Combination of observed and forecast if Start date is > current date.
3. Primary display element (forecast volume) options
  - a. Box and whiskers
  - b. 10%, 30%, 50%, 70%, or 90% exceedance probability volume
4. Secondary display element options
  - a. Daily observed volume to date if Start date is in the past.
  - b. Accumulated observed volume to date if Start date is in the past.
5. Context options
  - a. Average period volume

- b. Median period volume
  - c. Max and Min period volume
- 6. Date
  - a. User selectable
  - b. Default is current day.
- 7. Small table at the bottom provides the key data for the date selected
  - a. Period forecast (90%,50%,10% exceedance probabilities)
  - b. Observed to date

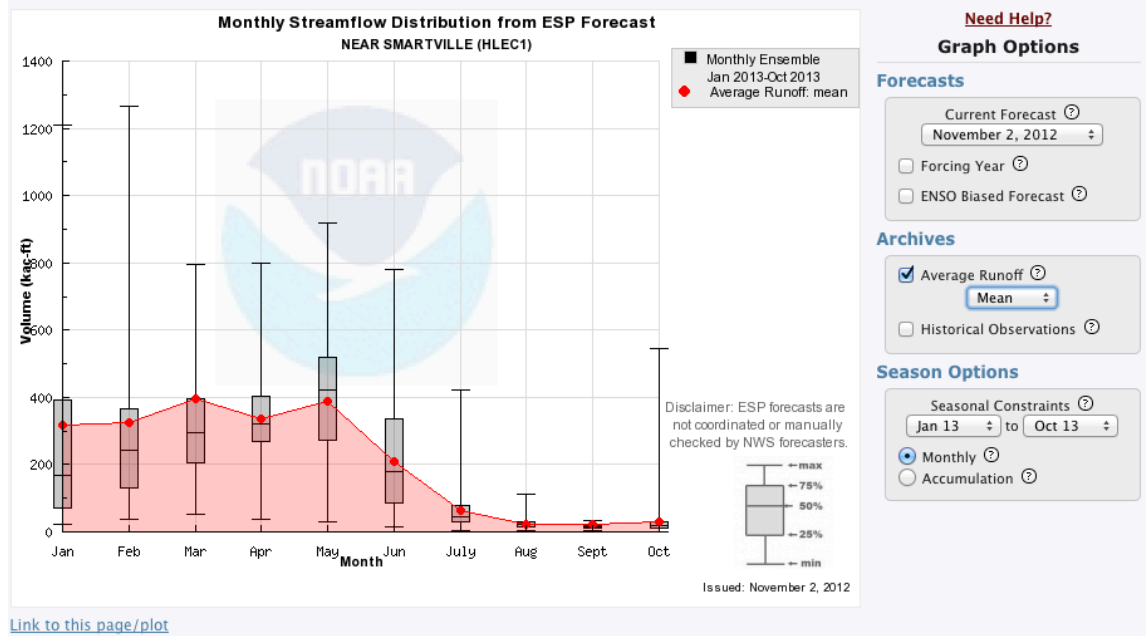
Use of this option for periods not pre-selected for analysis by the supporting RFC will require substantial analysis and the results may take several minutes to generate from resident forecast information. The user will be advised that they are requesting a non-standard period and asked if they wish to proceed understanding this request will take time to process. A record on non-standard period requests will be kept per forecast location in order to more efficiently manage the list of pre-selected periods managed by the supporting RFC. Data from non-standard period user requests will be stored in the system for 24 hours.

### Monthly Plot

- 1. Standard x-y plot
  - a. X-axis is time in months beginning with current month and extending to the last full month 365 days in the future.
  - b. Y-axis is monthly volume
- 2. Data plotted as box and whiskers
- 3. Context options
  - a. Average (default)
  - b. Median
  - c. Selected (analog) years
    - i. Single or multiple

## Ensemble Plot

Yuba River near Smartville, California (HLEC1 / CNRFC)



[Link to this page/plot](#)

Figure 6: Example of monthly plot showing average runoff ([wateroutlook.nwrfc.noaa.gov](http://wateroutlook.nwrfc.noaa.gov))

## Ranking Table

1. Table that compares current forecast with those of the past
2. User selectable period
  - a. Default is WY
3. See WRO for example.

## Forecast Ranking Table

Yuba River near Smartville, California (HLEC1 / CNRFC)

Flow Forecast in context with similar Historic Years (Apr - Jul, 1900 - 2012)

Apr-July

Change Period

[Need Help?](#)

Rank	Year	Flow (kaf)	Percent Mean
1	1952	2,424.09	116.5
2	1995	2,174.03	104.5
3	1983	2,131.61	102.5
4	1938	2,075.20	99.8
5	1922	2,044.30	98.3
6	1906	2,032.90	97.7
7	2011	2,017.03	97.0
8	1911	1,963.50	94.4
9	1907	1,953.90	93.9
10	1982	1,926.84	92.6
11	1958	1,913.70	92.0
12	2006	1,840.12	88.5
13	1998	1,815.75	87.3
14	1967	1,735.80	83.5
15	1969	1,721.00	82.7
16	1904	1,708.40	82.1
17	1915	1,652.10	79.4
18	1942	1,623.60	78.1
19	1916	1,573.50	75.6
20	1927	1,559.20	75.0
21	1914	1,553.70	74.7
22	1935	1,547.20	74.4
23	1917	1,532.20	73.7
24	1909	1,480.80	71.2
25	1996	1,457.09	70.1
26	2005	1,445.43	69.5
27	1941	1,434.55	69.0
28	1963	1,426.08	68.6
29	1975	1,412.45	67.9
30	1948	1,406.07	67.6
31	1993	1,391.72	66.9
32	1974	1,385.50	66.6
33	1971	1,380.00	66.3
34	1902	1,364.20	65.6
35	1901	1,346.50	64.7

Figure 7: Example ranking table

## **8. Meta / Background Data (provided by RFCs)**

1. Streamflow Forecast Points
  - a. Location (lat/lng)
  - b. Upstream / Downstream connectivity
  - c. Responsible RFC
  - d. Standard analysis period(s)
    - i. Default is WY
    - ii. Whole months
    - iii. As many as required by customers (e.g. Apr-Jul, Jan-Sept, etc.)
  - e. Observed data attribution
    - i. Estimated, observed, simulated, etc.
  - f. Ensemble attribution
    - i. .CS
    - ii. forcing type
    - iii. special notes or considerations
  - g. Monthly volume normal (KAF)
  - h. Daily historical time series data
    - i. Available period of record
    - ii. Simulated
    - iii. "observed"
2. Reservoirs
  - a. Location (lat/lng)
  - b. Monthly 1<sup>st</sup> of month storage averages (KAF)
  - c. Capacity (KAF)
  - d. Confidentiality information
  - e. Daily/monthly historical storage data (KAF)
    - i. As available

## **9. RFC Forecasts and Information Provided Daily, 365 days/year**

1. Ensemble forecasts for each identified location.
  - a. 365 day minimum duration.
  - b. Minimum of 25 ensemble members
  - c. 12Z time basis
  - d. Reflect unregulated (natural) streamflow
2. “observed” daily volume for the same locations as (1).
  - a. 24 hrs ending at 12Z
  - b. Can be computed or simulated
  - c. Provided daily
  - d. Provisions for providing revised values back to the beginning of the water year.
3. “observed” reservoir storage
  - a. Daily (local midnight or 12Z)
  - b. Provisions for providing revised values back to the beginning of the water year.

## **10. Verification Information**

In the initial implementation, the verification information will be quite limited. Once hindcasts are developed under HEFS, the verification information will expand dramatically.

Website design is to allow for ready inclusion of verification information generated through HEFS. Expectation is for this information to become available late 2015.

1. Water year forecast plots that show individual daily forecasts with developing observations will provide anecdotal validation. Plots will be archived as each year is completed.
  - a. Allowance for RFCs to provide archived forecast data in order to generate additional historical WY plots.
2. Monthly plots
  - a. From archive of available forecast information.
  - b. Similar to monthly plot for individual point.